Appendix E
Essential Fish Habitat Assessment

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Essential Fish Habitat Assessment for the Proposed Expansion of the Strategic Petroleum Reserve

Mississippi, Louisiana, and Texas

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Appendix E
Essential Fish Habitat Assessment

E.1 INTRODUCTION

This document presents the assessment of the Essential Fish Habitat (EFH) survey conducted by the Department of Energy (DOE) for the proposed expansion of the Strategic Petroleum Reserve (SPR). The assessment fulfills a requirement of the Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended through 1996 (Magnuson-Stevens Act).

This EFH assessment was prepared in conjunction with the Draft Environmental Impact Statement prepared for consideration of the proposed expansion of the SPR.

The objectives of this EFH assessment are to describe how the actions proposed by DOE may affect EFHs designated by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) and Gulf of Mexico Fisheries Management Council (GMFMC) in the area of proposed project sites. According to the GMFMC, EFHs in the Gulf of Mexico include all estuarine and marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone. The Exclusive Economic Zone is the area under national jurisdiction (up to 200-nautical miles [370 kilometers] wide) declared in line with the provisions of 1982 United Nations Convention of the Law of the Sea, within which the coastal nation has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources.

This assessment describes the proposed action and analyzes the direct and indirect effects on EFHs for the managed fish species and their major food sources. This assessment also presents the conclusions regarding the effects of the proposed action and alternatives and proposed mitigation measures.

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E.2 PROJECT DESCRIPTION

The Strategic Petroleum Reserve (SPR) was created in the 1970s to protect the United States from interruptions in petroleum supplies that could be detrimental to our energy security, National security, and economy. Congress mandated creation of the SPR in the Energy Policy and Conservation Act (EPCA) of 1975, and established as a national goal the storage of up to 1 billion barrels of crude oil and petroleum products. The current storage capacity of the SPR is 727 million barrels (MMB). Section 301(e) of the Energy Policy Act (EPACT), Public Law 109-58, enacted on August 8, 2005, directs the Secretary of Energy to:

> "… acquire petroleum in quantities sufficient to fill the Strategic Petroleum Reserve to the 1,000,000,000 barrel capacity authorized under Section 154(a) of the Energy Policy and Conservation Act …"

and Section 303 directs:

> "Not later than 1 year after the date of enactment of this Act, the Secretary shall complete a proceeding to select, from sites that the Secretary has previously studied, sites necessary to enable acquisition by the Secretary of the full authorized volume of the Strategic Petroleum Reserve. In such proceeding, the Secretary shall first consider and give preference to the five sites which the Secretary previously assessed in the Draft Environmental Impact Statement, DOE/EIS–0165–D. However, the Secretary in his discretion may select other sites as proposed by a State where a site has been previously studied by the Secretary to meet the full authorized volume of the Strategic Petroleum Reserve."

In response to these directives the purpose and need for agency action is to fill the SPR to the full authorized 1,000,000,000-barrel capacity (1,000-MMB) and by selecting sites to expand the current 727 MMB storage capacity.

The SPR, which is operated by DOE, currently consists of four underground oil storage facilities along the Gulf Coast: two in Louisiana (Bayou Choctaw and West Hackberry) and two in Texas (Big Hill and Bryan Mound). In addition, an administrative facility is located in New Orleans, LA. At the storage facilities, crude oil is stored in caverns constructed by the solution mining of rock salt formations (salt domes). The four SPR facilities have a current storage capacity of 727 MMB.

E.2.1 Proposed Action and Alternatives

The proposed action is to expand SPR storage capacity from its existing storage capacity of 727 MMB to 1 billion barrels (1,000 MMB). To obtain the additional 273 MMB of storage capacity, DOE would develop one of the following new sites:

- Bruinsburg, MS (160 MMB);
- Chacahoula, LA ((160 MMB);
- Clovelly, LA (120 MMB);
- Clovelly (80 or 90 MMB) and Bruinsburg (80 MMB);
- Richton, MS (160 MMB); or
- Stratton Ridge, TX (160 MMB)

In addition to developing a new site or a combination of two new sites, DOE would expand capacity at existing DOE SPR sites, namely Big Hill, TX, and possibly at Bayou Choctaw, LA, and/or West

Hackberry, LA. DOE will consider a 72, 80, 84, 96, or 108 million barrel capacity expansion at Big Hill, a 20 or 30 million barrel capacity expansion at Bayou Choctaw, and no expansion or a 15 million barrel capacity expansion at West Hackberry.

These combinations of potential new and expansion sites will allow DOE to assess a wide range of alternative configurations to achieve the 1 billion barrel storage capacity, as mandated by the Energy Policy Act of 2005. The assessment of each site will include consideration of ancillary offsite facilities including pipelines to crude oil transportation and distribution complexes.

For the proposed new and expansion sites, DOE would create oil storage caverns in underground rock salt formations, except for West Hackberry where DOE would buy existing caverns. Caverns would be constructed through a technique known as solution mining using fresh or salt water. Leaching generates approximately 80 million barrels of concentrated brine wastewater per 10 million barrels in cavern space created. This wastewater would be disposed of either by pipeline to diffusers in the Gulf of Mexico or to an array of underground injection wells.

To supply the water to a new site, a raw water intake structure would be constructed offsite in a surface water body (a canal, the Intracoastal Waterway, the Mississippi River, or the Leaf River). The water and brine systems for leaching caverns would be sized to supply up to 1.2 million barrels per day and the crude oil distribution system would be designed for drawdown up to one million barrels per day. The proposed expansions of existing SPR facilities would, in general, use the existing infrastructure and pipelines of the oil storage site. The location of the existing and proposed offshore pipelines and diffusers are shown in figures E.5-1 through E.5-5.

Brine from three of the sites (Bruinsburg, Bayou Choctaw, and West Hackberry) would be injected into the deep subsurface aquifer via injection wells. At the remaining sites listed below, brine would be discharged into the Gulf of Mexico through diffusers. Brine discharge via pipeline rights-of-way (ROWs) to the Gulf of Mexico would occur at the following proposed sites (see figure E.2-1: Proposed Locations of SPR Brine Diffusers in the Gulf of Mexico).

- Chacahoula, LA (new site, brine pipeline, and diffuser);
- Clovelly, LA (new site with brine discharged through an existing diffuser at the LOOP facility);
- Clovelly-Bruinsburg (new sites with brine from Clovelly discharged through an existing diffuser at the LOOP facility);
- Richton, MS (new site, brine pipeline, and diffuser);
- Stratton Ridge, TX (new site, brine pipeline, and diffuser); and
- Big Hill, TX (expansion of existing SPR brine would discharge through an existing diffuser).

E.3 ESSENTIAL FISH HABITAT

Essential fish habitat is defined in the Sustainable Fisheries Act (1996) as those “waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” The identification of the different habitat types in the Gulf of Mexico region has several different types of EFH that are necessary for one commercially important species or another during different stages of their life cycle.

The different types of EFH identified in the proposed project areas would be affected by construction of the brine disposal pipelines. The daily operation of the facility, including periodic maintenance of pipeline ROWs and the discharge of brine and brine diffusion, would have much less potential to affect these habitats. The project does not propose to construct RWI structures in EFH areas.

E.3.1 Estuarine Emergent Wetlands

An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water mixes with fresh water. The key feature of an estuary is that it is a mixing place for sea water and a stream or river to supply fresh water. A tide is a necessary component to maintain a dynamic relationship between the two waters. Estuaries occur on submerged coasts where the sea level has risen in relation to the land.

Emergent wetlands are wetlands that are defined by erect, rooted, herbaceous hydrophytic plants. The estuarine environment is defined by the presence of ocean-derived salt with salinity greater than 0.5 percent, and the area is partially or wholly enclosed by land, but it is influenced by oceanic and freshwater sources. Estuarine emergent wetlands are defined in a similar way to estuarine environment, characterized by erect, rooted, herbaceous hydrophytes, but are dominated by halophytic plants such as smooth cord grass (*Spartina alterniflora*).

The estuarine emergent wetlands are a prevalent habitat type along the Gulf Coast. The estuarine emergent wetlands go through periods during low tides when most of the water has receded from the vegetated area, leaving the plants and substrate exposed. These areas are important nurseries for juvenile species of fish and invertebrates. The vegetation provides protection and shelter from larger predators and offers a small habitat for the species to mature (Cowardin, 1979).

E.3.2 Mud, Sand, and Shell Substrates

The different commercially important species found in the Gulf Coast region show preferences to different types of substrates. Species such as shrimp would prefer the muddy substrate because it allows them to forage for food that lives in the substrate. Aside from the commercially important species that can be found in the area, many species of mollusks, polychaetes, oligochaetes, and annelids can be found in or on the muddy or sandy substrate.

The shell substrate is created by oysters that form large reefs, creating an entirely different substrate type. Similar to the sand and mud substrate, many other non-commercially important species can be found in this habitat. Some juvenile fish use these areas for feeding and protection from predators.

E.3.3 Submerged Aquatic Vegetation

Submerged aquatic vegetation, as defined by the Gulf of Mexico Fishery Management Council, is “rooted vascular plants that, except for some flowering structures, live and grow below the water surface.” Submerged aquatic vegetation is a sensitive type of EFH, and often accommodates many managed species in the Gulf during some life stage. The offshore brine pipelines associated with Stratton Ridge and Richton may encounter submerged aquatic vegetation during the construction process. DOE would attempt during the more detailed design stage to avoid these areas during the formal pipeline survey and alignment.

Near Stratton Ridge, there are several different species of submerged aquatic vegetation that occur in the Galveston Bay ecosystem. The different types of submerged aquatic vegetation are shoalgrass (*Halodule wrightii*), wigeongrass (*Ruppia maritima*), and turtle grass (*Thalassia testudinum*). These grasses occur mostly to the northeast in Christmas Bay and Drum Lake, away from the brine pipeline ROW.

The brine pipeline associated with the proposed Richton site would pass near the areas of seagrasses in the Gulf Islands National Shoreline. The species of seagrasses that exist in the proposed project site are shoalgrass (*Halodule wrightii*), wigeongrass (*Ruppia maritima*), and manatee grass (*Syringodium filiforme*). The seagrass beds are sporadically located throughout the system along the barrier islands. Shoalgrass and manatee grass are found on the northern side of the barrier islands in the Gulf Islands National Shoreline where they are protected from the higher wave energy of the open Gulf.

E.3.4 Estuarine and Marine Water Columns

The water column makes up the largest portion of the habitat types in the aquatic environment. The pelagic ecosystem can be home to many species of commercially important fishes. Species such as greater amberjack, tunas, dolphinfish, and cobia are all pelagic species that are found in the Gulf of Mexico. The water column is equally important in the estuarine environment; many of the top tier predators and commercially important species can be found in the pelagic environment. The pelagic environment is home to phytoplankton, the primary producers of the water column, and the start of the food web.

E.3.5 Artificial Reefs

Artificial reefs are manmade structures that create habitat for marine life. These structures can include concrete rubble, sunken ships, and oil rigs (active and decommissioned). Objects used for creation of artificial reefs depend on the water depth. Shallow waters (72-102 feet, 21-31 meters) use concrete rubble, old bridges, and concrete scrap, and beyond 102 feet (31 meters) use decommissioned oil rigs, and even deeper waters that can be home to sunken ships (Texas Parks and Wildlife, 2006). Each of the states along the Gulf has created artificial reef programs that aim to aid operating companies in ecologically sound disposal of decommissioned oil rigs and ships for the conversion to artificial reefs. These artificial reefs provide new, artificial habitat for marine life in areas that may otherwise be devoid of benthic structure. Many fishes can be found associated with the artificial reefs, including snappers, groupers, jacks, sharks, and some reef species.

The larger artificial reefs, for the most part, are located in deeper waters than the proposed brine pipelines or diffusers—beyond 17 fathoms (102 feet, 31 meters). It is not expected that the brine disposal system, would adversely affect the artificial reefs of the Gulf of Mexico. The maximum depth at the terminus of the brine diffusers for any of the sites would be 47 feet (14 meters) for the proposed Richton site. This depth is within the limits of the use of concrete rubble for artificial reefs but not within the depth acceptable for the use of oil rigs and ships.

E.4 MANAGED SPECIES

Many species found in the Gulf of Mexico are highly valued for commercial purposes. Whether taken to market, processed for meal, or used for supplement extraction, these species require management for the prevention of over-harvesting. NOAA Fisheries and the equivalent state agencies are the two main bodies that work to manage fisheries in the United States. Under the guidance of the Magnuson-Stevens Fisheries Conservation and Management Act and the Sustainable Fisheries Act, NOAA Fisheries and the respective state agencies have created their own guidelines with limits and quotas for the management of the fisheries within their waters.

The species assessed in this document are those most likely to occur within the project areas. Other managed species were considered and determined to be unaffected by the proposed project because of two main factors: (1) they do not occur in shallow waters; or (2) they do not occur in the geographic project area.

E.4.1 Shrimp Fishery

The shrimp fishery is an economically important fishery in the Gulf of Mexico. The shrimp fishery is composed of three different species, which are harvested in commercial quantities throughout the Gulf Coast region. The three main species harvested are the brown, pink, and white shrimp. Each of these species has commercial importance throughout the different proposed project areas.

E.4.1.1 Brown Shrimp

Although they are most abundant in the central and western part of the Gulf of Mexico, brown shrimp (*Farfantepenaeus aztecus*) occur throughout the coastal Gulf region and its associated inshore estuarine environments. Brown shrimp larvae are found offshore, but migrate to inshore estuaries as postlarvae, with the height of migration occurring in late winter and early spring. The silt and mud substrate common to Gulf estuaries provides the juvenile brown shrimp diet, which includes detritus, algae, polychaetes, amphipods, nematodes, ostracods, chironomid larvae, and mysids (Lassuy, 1983). As adults, brown shrimp move from estuaries to areas further offshore, and they can be found at water depths of up to 360 feet (109 meters). Adults will reach maturity within a year of moving offshore. Typically, fluctuations in temperature or salinity levels do not cause direct mortality. Postlarvae and juveniles have been collected in salinity levels up to 70 parts per thousand (GMFMC, 1998a), but that level may reduce vigor and increase vulnerability to predation. In addition, juveniles may leave estuaries early if large freshwater inflows occur and lower the salinity concentration (Larson, et al., 1989).

E.4.1.2 Pink Shrimp

Pink shrimp (*Farfantepanaeus duorarum*) larvae begin life offshore, but juveniles move to estuarine and coastal bay nursery areas with soft sand or mud substrate mixture containing sea grasses. Recruitment of the postlarvae most often occurs in the spring and late fall during flood tides. The juveniles, which remain in nursery areas for 2 to 6 months, forage at night or in turbid conditions during the day. During this time, juvenile pink shrimp prey on a wide variety of organisms including foraminifera, diatoms, dinoflagellates, nematodes, polychaetes, and others (Bielsa, et al., 1983). Potential prey species for juvenile pink shrimp are vulnerable to dredging activities, such as would be required for laying and burying the brine pipelines, but they would recover quickly (Culter and Mahadevan, 1982). After the juveniles reach a certain length, they move offshore, with the principal peak of emigration from nurseries occurring in the fall. Adult pink shrimp are most commonly found at a depth of between 29 and 144 feet (9 and 44 meters), but have been found as deep as 361 feet (110 meters). Spawning for adult pink shrimp most often occurs in the spring, but they can spawn at any time year-round, usually at depths between 12 and 156 feet (4 and 48 meters).

Pink shrimp prefer different salinity levels at various life stages. Post-larval and juvenile shrimp are generally found at lower salinities in their estuarine environments, and they have been collected at salinities as low as between 12 and 5 parts per thousand, respectively. Adult pink shrimp prefer saltier oceanic water; they have been collected from seawater ranging in salinity from 25 to 45 parts per thousand (Bielsa et al., 1983).

E.4.1.3 White Shrimp

Like pink and brown shrimp, white shrimp (*Litopenaeus setiferus*) are offshore and estuarine dwellers that are pelagic as larvae and become demersal depending on their life stage. Two to three weeks after they hatch offshore, postlarval white shrimp travel to estuaries that serve as nursery areas (Williams, et al., 1990). Juvenile white shrimp seek shallow water with muddy-sand bottoms, and they are invaluable for coastal food chains because they recycle organic matter by feeding on organic matter and detritus in the sediment (Williams, et al., 1990). As juveniles mature, they move to nearshore, demersal habitats that are less than 100 feet (30 meters) deep and generally prefer muddy substrates. Like the brown shrimp, white shrimp prefer higher salinity waters as they mature from the juvenile to adult life stage. Spawning will only occur in waters where salinity is at least 27 parts per thousand, and the depth is between 26 and 101 feet (8 and 31 meters).

E.4.2 Red Drum Fishery

The red drum (*Sciaenops ocellatus*) is one of the most economically important fish in the Gulf of Mexico. Although commercial harvest is not permitted, recreational capture is allowed. The red drum is common throughout the Gulf Coast system, most prevalent in the bays and estuaries, but it can be found along the beachfronts in areas with elevated salinities. The majority of the life cycle is spent in bays and estuaries, and red drum only venture offshore for spawning. The eggs and early larval stage follow the currents and migrate back into the bays and estuaries.

Red drums are found in both marine nearshore habitats and estuarine waters, most commonly over sandy bottoms where they prey on fish, crabs, shrimp, sand dollars, and other invertebrates (Manooch, 1984). Larvae are found in vegetated or unvegetated bottoms in estuaries, tidal flats, and open bays at temperatures ranging from 64 to 87 ^{o}F (18 to 31 ^{o}C), and salinities ranging from 16 to 36 parts per thousand. Optimal conditions are considered to be 77 ^{o}F (25 ^{o}C) and 30 parts per thousand for this species (Buckley, 1984; Holt, et al., 1981; Pattillo, et al., 1997; Peters and McMichaels, 1987). Early juveniles are found in backwaters, tidal flats, primary and secondary bays, and open water mud bottoms at depths up to 9.8 feet (3 meters) and temperatures ranging from 54 to 90 ^{o}F (12 to 32 ^{o}C), and salinities from 0 to 45 parts per thousand (20 to 40 parts per thousand optimal) (Buckley, 1984; Holt, et al., 1981; Pattillo, et al., 1997; Peters and McMichaels, 1987; GMFMC, 1998b).

Juveniles cannot survive in ponds with less than 0.6 to 1.8 parts per million dissolved oxygen. Late juveniles are found in continental shelf and inshore waters at depths slightly greater than those of early juveniles, with temperatures ranging from 71 to 84 ^{o}F (22 to 29 ^{o}C) and salinities ranging from 25 to 45 parts per thousand (Buckley, 1984; Holt, et al., 1981; Pattillo, et al., 1997; Peters and McMichaels, 1987). Adult red drums are found in continental shelf and inshore waters at depths from 131 to 229 feet (40 to 70 meters), temperatures ranging from 35 to 91 ^{o}F (2 to 33 ^{o}C), and typical salinities of 30 to 35 parts per thousand, although the species can tolerate up to 50 parts per thousand (Lyczkowski-Shultz, et al., 1987; Holt, et al., 1981; Pattillo, et al., 1997; Peters and McMichaels, 1987).

E.4.3 Reef Fishery

In 1984, the Gulf of Mexico Reef Fishery Management Plan was one of the first to be developed by the Gulf Fishery Management Council. The goal outlined in the plan was to, “manage the reef fish fishery of the United States waters of the Gulf of Mexico to attain the greatest overall benefit to the nation with particular reference to food production and recreational opportunities on the basis of maximum sustainable yield as modified by relevant economic, social or ecological factors." A series of amendments to the initial Reef Fishery Management Plan have provided updated policies for 42 species of reef fish that are of commercial or recreational importance in the Gulf of Mexico. Five families of fish—grouper, snapper, tilefish, triggerfish, and jack—account for approximately 95 percent of the reef fish landings in the Gulf. The vast majority of that (about 95 percent by weight) is made up of groupers and snappers (GMFMC, 2004).

The EFHs for reef fish species range from estuarine environments to offshore waters with depths of up to 1,640 feet (500 meters). Many of the species managed under the Reef Fish Management Plan occupy both benthic and pelagic environments depending on life-cycle phase. Larval reef fishes are planktonic, and they occupy the water column feeding on phytoplankton and smaller zooplankton. Some species of reef fish spend their larval phases in estuaries and inland seagrass beds before moving offshore as adults. Mature reef fish are generally demersal, and they are associated with high-relief bottom topographies (e.g., reefs, cliffs and outcroppings) on the continental shelf (GMFMC, 1998c).

Reef fish are also attracted to artificial reefs that may be intentionally constructed to encourage growth of fish stocks, or they may occur incidentally when a structure is constructed for different purposes but doubles as a reef environment. Petroleum operations, particularly in the northwest corner of the Gulf, have led to the construction of several artificial structures that are currently inhabited by Fishery Management Council-regulated species (GMFMC, 1998c).

E.4.3.1 Red Grouper

Red Grouper *(Epinephelus morio)* is the most widely distributed species of grouper and ranges throughout the Gulf of Mexico (Jory and Iversen, 1989). The larval stage for the red grouper lasts from 30 to 40 days, and the species is planktonic in the pelagic zone during that time (Moe, 1969). When the grouper matures to the juvenile phase of the life cycle, it is generally associated with inshore hard-bottom habitat, grassbeds, and rock formations where it preys on demersal crustaceans (Jory and Iversen, 1989). Adult groupers move farther offshore as they grow. They are most often found at depths of 100 to 400 feet (30 to 121 meters) (NOAA Fisheries, 2004). Groupers are most common in areas with average ocean salinities (30 to 35 parts per thousand), although young juveniles may move into waters where salinity is as low as 20 parts per thousand. Spawning adult groupers must inhabit water with salinity of at least 32 parts per thousand for the eggs to float (Hardy, 1978; Roe, 1976).

E.4.3.2 Greater Amberjack

Greater amberjacks (*Seriola dumerili*) are abundant in the Gulf of Mexico and are frequently encountered near structures such as reefs, sargassum patches, and oil rigs in waters ranging in depth from 65 to 1,099 feet (20 to 335 meters) (Duedero, et al., 1999; Massuti, et al., 1999). Greater amberjacks are top-level predators that feed on a variety of fishes, crustaceans, and cephalopods (Berry and Smith-Vaniz, 1977). Larvae are found in offshore open waters, most likely in warm, summer temperatures, and typical open Gulf salinity levels of 30 to 35 parts per thousand (Fahay, 1975; Thompson, 2005). Juveniles are pelagic, often associated with rip lines and floating structures, in waters with typical open Gulf salinity levels of 30 parts per thousand and above (Thompson, 2005). Adult greater amberjacks are also pelagic, but have been observed at depths ranging from surface to several hundred feet (meters) deep. Adults prefer waters with typical salinity levels of 30 parts per thousand and above, but become more scarce in waters with temperatures under 64 to 68 °F (18 to 20 °C) (Thompson, 2005; Berry and Smith-Vaniz, 1977; Fahay, 1975; Burch, 1979).

E.4.3.3 Tilefish

Tilefish (*Lopholatilus chamaeleonticeps*) are benthic and inhabit the outer continental shelf in the Gulf of Mexico at depths typically greater than 820 feet (250 meters) and temperatures ranging from 48 to 57 $^{\circ}$F (9 to 14.4 ^{o}C) (Able, et al., 1987; Freeman and Turner, 1977). They are found in and around submarine canyons where they dig burrows in the sedimentary substrate (Nitschke, 2000). They predominately feed on crustaceans, fishes, and other benthic organisms (Freeman and Turner, 1977).

E.4.4 Coastal Migratory Pelagic Fishery

The coastal migratory pelagic fishery comprises many different species. Many top-tier predators such as cobia, dolphinfish, and mackerel are commercially and recreationally sought in the Gulf of Mexico. In addition to the top-tier predators, some primary consumers are important to many commercial fishermen (e.g., gulf menhaden).

E.4.4.1 Cobia

Cobia (*Rachycentron canadum*) are large pelagic fish that are distributed globally in tropical and subtropical waters including the coastal Gulf of Mexico. Cobia larvae occur in estuarine, nearshore and offshore locations, and they can be found near the surface or at depths of up to 984 feet (300 meters). The larvae are known to sustain greater salinity variation than more developed fish, and they can be reared at salinities as low as 19 parts per thousand (Ditty and Shaw, 1992; Hardy, 1978; Hassler and Rainville, 1975). Juvenile nursery and adult habitat overlap and include coastal areas, bays, and river mouths. Adult cobia, surviving on benthic invertebrates, follow general migration patterns—spring and summer in the northern Gulf, winter and fall in the southern Gulf. Spawning for cobia occurs in April through September in the northern Gulf of Mexico (Shaffer, et al., 1989; Boschung, 1957; Meyer and Franks, 1996; Knapp, 1951; Miles, 1949; Reid, 1954; Springer and Woodburn, 1960; Christmas and Waller, 1974). In addition to living in a narrow range of salinities, cobia are attracted to underwater structures such as pilings and wrecks, and they follow floating debris (Mills, 2000).

E.4.4.2 Dolphinfish

Dolphinfish (*Coryphaena hippurus*) are predatory oceanic fish that are limited to waters with high salinities (32 to 35 parts per thousand). They rarely travel to coastal waters (Oceanic Institute, 1993). Spawning of the species is poorly documented, but it is thought to occur nearly year-round in the Gulf, with a peak in the early fall. Dolphinfish larvae grow rapidly and reach maturity within one year of hatching. As with the adults, larvae and juveniles thrive in higher salinities and do not often occur in estuarine or coastal waters (GMFMC, 1998d). Young dolphinfish are most common at depths greater than 590 feet (180 meters), and adults can occur as deep as 5,900 feet (1,800 meters), although they are most common between 131 and 656 feet (40 and 200 meters) (Powles, 1981; Gibbs and Collette, 1959; Schuck, 1951; Ditty, et al., 1994). As with cobia, dolphinfish are attracted to floating objects and often aggregate around floating debris (Palko, et al., 1982). Dolphinfish also thrive in the Mississippi River plume, and they are particularly abundant in waters around the mouth of the Mississippi.

E.4.4.3 Gulf Menhaden

Gulf Menhaden (*Brevoortia patronus*) occur mostly inshore in the Mississippi Delta area in summer and largely move into deeper water in the fall. They feed in dense schools, filtering phytoplankton, but possibly also feed at the bottom. Spawning occurs from October to February, with a peak in January. Salinity tolerance ranges from 0.1 to 60 points per thousand, but the commercial catch is taken mostly from salinity from 5 to 24 parts per thousand. Larvae stay in offshore waters for 3 to 5 weeks before moving into estuaries where they grow into adults (Patillo et al, 1997).

Commercial fisheries target this species because of the versatility they offer with products, from meal, to oils, to foodstuffs. Gulf menhaden are marketed fresh, salted, or canned, but mainly they are used as a source of fish oil and fishmeal. Construction of the SPR facilities and associated pipelines is not expected to have an impact on the commercial fishery.

E.4.4.4 King Mackerel

King mackerel (*Scomberomorus cavalla*) are found throughout the Gulf of Mexico, and they range throughout the neritic zone from close to shore to depths of 656 feet (200 meters). Spawning of king mackerel occurs throughout its range and peaks from May to October. Eggs and larvae are pelagic over depths of 98 to 590 feet (30 to 180 meters); optimally they grow in salinities more than 30 parts per thousand (Dwinell and Futch, 1973; Godcharles and Murphy, 1986; Nakamura, 1987). Although juveniles may occasionally use estuaries as nurseries, they generally live in nearshore shelf waters at depths of less than 29 feet (9 meters). As king mackerel grow, they prey on larger species of pelagic fish and squid, moving farther offshore to the edge of the continental shelf (Godcharles and Murphy, 1986).

E.4.4.5 Spanish Mackerel

Spanish Mackerel (*Scomberomorus maculates*) are primarily a neritic species, but in rare cases they inhabit inshore and estuarine waters (GMFMC, 1998d). Spanish mackerel larvae are most successful in inner continental shelf environments with salinity ranging from 28 to 37 parts per thousand, and at depths greater than 164 feet (50 meters) (Dwinell and Futch, 1973). Spanish mackerel is very similar to king mackerel in diet, and they prey primarily on pelagic fish, especially clupeids, engraulids, and carangids (GMFMC, 1998d).

E.4.5 Spiny Lobster Fishery

Although adult spiny lobsters (*Panulirus argus*) inhabit bays, lagoons, salty estuaries, and shallow banks, spawning for the spiny lobster takes place along the deeper reef fringes. After the larvae hatch, they live in the epipelagic for 6 to 12 months and exist in an offshore environment marked by relatively constant temperature and salinity, low levels of suspended sediments, and few pollutants (GMFMC, 1998f). Recruitment begins when the larval spiny lobsters adopt a secondary morphology with specialized abdominal pleopods that allow the lobsters to migrate to the nearshore. These migrations correspond with new and first quarter lunar phases (Marx and Herrnkind, 1986). The juvenile initially settle in macroalgae beds along rocky shorelines and feed on mollusks and other crustaceans. As the spiny lobster continues to grow and molt, it settles on larger biotic and abiotic structures. Adults eventually inhabit crevices in coral reefs and rock formations. Both the juveniles and adults are stenohaline, and optimally survive in water with a salinity of 32 to 36 parts per thousand (NOAA Panama City Laboratory, 2005; Buesa, 1979; Fields and Butler, 1994).

E.4.6 Highly Migratory Species

According the Fishery Conservation Amendments of 1990, (Public Law 101-627) highly migratory species (HMS) found in the deep waters of the Atlantic Ocean and Gulf of Mexico include: albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), marlin (*Tetrapturus* spp. and *Makaira* spp.), oceanic sharks, sailfishes (*Istiophorus* spp.), and swordfish (*Xiphias gladius*). These HMS usually feed in deep water.

E.4.6.1 Albacore Tuna

Albacore tuna (*Thunnus alalunga*) are epipelagic and mesopelagic, and are found in oceanic surface waters between 60 to 67 °F (15 to 19 °C); deeper swimming, large albacore are found in waters of 56 to 78 °F (13 to 25 °C); temperatures as low as 49.1 °F (9.5 °C) may be tolerated for short periods. The species is known to concentrate along thermal discontinuities. It forms mixed schools with skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and bluefin tuna (*T. maccoyii*). Schools may be associated with floating objects including sargassum weeds. Primary prey includes fishes, crustaceans, and squids. Sexual maturity is reached at 35 inches (90 centimeters). Albacore tuna has high market demand.

E.4.6.2 Bigeye Tuna

Bigeye tuna (*Thunnus obesus*) occur in areas where water temperatures range from 55 to 84 °F (13 to 29 °C), but the optimum temperature for the species is between 62 and 71 °F (17 and 22 °C). Variation in occurrence is closely related to seasonal and climatic changes in surface temperature and thermocline. Juveniles and small adults collect in schools at the surface in monospecies groups or mixed with other tunas, and the schools may be associated with floating objects. Adults stay in deeper waters. Eggs and larvae are pelagic. Bigeyes feed on a wide variety of fishes, cephalopods, and crustaceans during the day and at night.

E.4.6.3 Blue Marlin

Blue Marlin (*Makaira nigricans*) is an oceanic species. Water color affects its occurrence, at least in the northern Gulf of Mexico, where the fish show preference for blue water. The species rarely gathers in schools, and it usually occurs as scattered individuals. Blue marlin feed mainly on fishes, but they also prey on octopods and squids. Feeding takes place during daytime. Sexual maturity in males is reached at about 32 inches (82 centimeters) in length and 90 pounds (40 kilograms) and for females 20 inches in length (50 centimeters) and 60 pounds (27 kilograms).

E.4.6.4 Bluefin Tuna

Bluefin Tuna (*Thunnus thynnus*) is primarily an oceanic species, but it can tolerate a wide range of temperatures, and seasonally it comes close to shore. It gathers in schools by size, and sometimes together with albacore, yellowfin, bigeye, skipjack tunas. It preys on small schooling fishes (anchovies, sauries, hakes) or on squids and red crabs. The species is pelagic and oceanodromous, and it is found in brackish to marine waters at a depth range 0 to 9,840 feet (0 to 3,000 meters). Bluefin tuna have become rare because of massive overfishing.

E.4.6.5 Skipjack Tuna

Skipjack tunas (*Katsuwonus pelamis*) are found in offshore waters. The larvae are restricted to waters with surface temperatures of 59 to 86 °F (15 to 30 °C). They exhibit a strong tendency to school in surface waters with birds, drifting objects, sharks, and whales and may show a characteristic behavior like jumping, feeding, foaming, etc. Skipjacks feed on fishes, crustaceans, cephalopods, and mollusks; cannibalism is common. They are preyed upon by large pelagic fishes. Skipjack tunas are marketed fresh, frozen or canned, dried-salted, and smoked. They spawn throughout the year in the tropics.

E.4.6.6 Swordfish

Swordfish are an oceanic species but sometimes are found in coastal waters. They generally live above the thermocline, preferring temperatures of 64 to 71 °F (18 °C to 22 °C). Larvae are frequently encountered at temperatures above 75 °F (24 °C). The larvae migrate toward temperate or cold waters in the summer, and then back to warm waters in the fall. Larger individuals may accumulate high concentrations of mercury in their flesh. In the Atlantic, spawning, which occurs in spring, takes place in the southern Sargasso Sea. The females grow faster than males. Age determination is difficult because the otoliths are very small and scales are missing in adults. Eggs are pelagic and measure 0.06 to 0.07 inches (1.6 to 1.8 millimeters). Newly hatched larvae are 0.16 inches (4 millimeters) long. The sword is well developed at a length of 0.37 inches (10 millimeters), and the young live pelagically in the upper water layers, where they quickly develop into voracious predators. The adults are opportunistic feeders, known to forage for their food from the surface to the bottom over a wide depth range. They use their sword to kill their prey, and feed mainly on fishes, crustaceans, and squids.

E.4.6.7 White Marlin

White Marlin (*Tetrapturus albidus*) are usually found above the thermocline. Its distribution varies seasonally, reaching higher latitudes in both the northern and southern hemispheres only during the respective warm seasons. The species is usually found in deep blue water (328 feet, 100 meters) with surface temperatures higher than 71 °F (22 °C) and salinities of 35 to 37 parts per thousand. Currents of 0.5 to 2 nautical miles per hour (0.9 to 3.7 kilometers per hour) occur over much of its habitat. White marlin feed on fishes and squids.

E.4.6.8 Yellowfin Tuna

Yellowfin Tuna (*Thunnus albacares*) are an oceanic species occurring above and below the thermoclines. They school primarily by size, either in monospecific or multispecies groups. Larger fish frequently gather in schools with porpoises, and they are associated with floating debris and other objects. Yellowfins feed on fishes, crustaceans, and squids. They are sensitive to low concentrations of oxygen, and therefore, they are not usually caught in waters deeper than 820 feet (250 meters) in the tropics. Peak spawning occurs in batches during the summer. Encircling nets are used to catch schools near the surface.

E.4.7 Stone Crab Fishery

The stone crab (*Menippe mercenaria*) fishery is a fairly small market in the northern Gulf of Mexico. The majority of the stone crab market comes from areas in southern Florida or southern Texas. The majority of the fishery is not located within the proposed project areas. Stone crabs do exist within the project area, but not in the larger numbers that exist in the southern Gulf of Mexico.

Stone crab larvae are hatched in the spring and fall in nearshore Gulf environments. The growth of the planktonic larvae depends on salinity and temperature, but stone crabs will usually progress through the larval stage in 14 to 27 days (Lindberg and Marshall, 1994). Juveniles settle in nearshore waters, and they can tolerate a broad range of temperature 46 to 100 ^{0}F (8 to 38 ^{0}C), and salinity (5 to 40 parts per thousand) (Brown, et al., 1992; Ong and Costlow, 1970). Both juveniles and adults are opportunistic carnivores. Adults dig and burrow to hide during hunting. Post-settlement juveniles hide in naturally occurring features such as shell hash habitat, sponges, and mats of seagrass (Culter and Mahadevan, 1982). Although they are occasionally found in the intertidal, adult stone crabs generally inhabit the shallow shelf seagrass flats and are specifically abundant in turtle grass (*Thalassia testudinum*). Adults are euryhaline and can survive in a wide range of salinities; however, they are most common in water with salinity of at least 15 parts per thousand (NOAA Panama City Laboratory, 2005; GMFMC, 1998e).

E.4.8 Snapper Fishery

The snapper fishery comprises many different species, but the primary species sought is the red snapper. The red snapper fishery is strictly regulated because of the sensitivity of the species, and annual bag limits are set based on previous years' landings. The commercial fishing season for red snapper is during the summer, but recreational fishing can take place year round. Other snapper species are also sought, including the gray snapper.

E.4.8.1 Gray Snapper

Gray snappers (*Lutjanus griseus*) are found in coastal and offshore waters associated with seagrass, mangroves, estuaries, lagoons, deep channels, and reefs (NatureServe, 2005). Adults of the species tend to remain in the same area. Juvenile gray snapper prefer inshore areas such as seagrass beds (especially *Thalassia* seagrass), soft- and sand-bottom areas, and mangrove roots (Starck and Schroeder, 1971). Both adults and juveniles have been found in freshwater lakes and rivers in south Florida, which indicates a tolerance of a broad range of salinity levels. Juveniles are typically found in temperatures ranging from 55 to 97 ^{o}F (12 ^{o}C to 36 ^{o}C) and low salinities ranging from 0 to 66 parts per thousand (Rutherford, et al., 1989; Rutherford, et al., 1983). Adults occur in waters with depths of 0 to 591 feet (0 to 180 meters), temperatures from 56 to 90 ^{o}F (13 ^{o}C to 32 ^{o}C), and salinities ranging from 0 to 47 parts per thousand (NatureServe, 2005; Wang and Raney, 1971).

E.4.8.2 Lane Snapper

Adult lane snappers (*Lutjanus synagris*) are found in a variety of habitats throughout its range, but are most commonly observed over reefs and vegetated sandy bottoms in shallow inshore waters (Bester and Murray, 2005). Lane snappers also occur in seagrass beds associated with shrimping areas and offshore waters to depths of 1,300 feet (400 meters) (Bester and Murray, 2005). After they are established, adult lane snappers remain in the same area for their entire lives. Because the lane snapper lives in a wide range of habitats, they are opportunistic predators, feeding on a variety of prey such as smaller fishes, shrimp, cephalopods, gastropods, and crabs. Juveniles prefer protected inshore areas and are often found in waters of low salinity - 15 parts per thousand or less (Bester and Murray, 2005; Erhardt, 1976). Adults are typically found in waters at depths of 13 to 433 feet (4 to 132 meters), temperatures between 60 to 82 ^{o}C (16 ^{o}C and 29 ^{o}C), and high salinities of 30 parts per thousand or greater (Bullis and Jones, 1976; Erhardt,1976).

E.4.8.3 Red Snapper

Red snapper (*Lutjanus campechanus*) larvae and juveniles are found in offshore continental shelf waters at depths ranging from 56 to 600 feet (17 to 183 meters), temperatures ranging from 63 to 85 ^{o}F (17 to 29 ^{o}C), and salinities ranging from 32 to 37 parts per thousand. Juveniles are most often observed in association with structures, objects, or small burrows and they are less likely to be observed over barren bottoms (Collins, et al., 1980; Moseley, 1966). Adults are found in large abundance off the Yucatan, Texas, and Louisiana coasts over areas of hard limestone or gravel bottoms and irregular bottom formations including deep reefs. Adult red snappers are found in waters at depths from 132 to 361 feet (40 to 110 meters), temperatures ranging from 57 to 86 ^{o}F (14 to 30 ^{o}C), and salinities ranging from 33 to 37 parts per thousand. The red snapper is a carnivorous fish, feeding primarily on a variety of smaller fishes, squid, octopus, crustaceans, and mollusks (Bester, 2005b).

E.4.8.4 Yellowtail Snapper

Adult yellowtail snappers (*Ocyurus chrysurus*) are semipelagic, and, typically are found over sandy or hard bottom areas near deep reefs at depths of 32 to 230 feet (10 to 70 meters) (Bester, 2005a). After they are established, adult yellowtail snappers tend to remain in the same area for long periods of time (Bester, 2005a). They feed predominately on benthic and pelagic reef fishes, crustaceans, and mollusks (Randall, 1967; GMFMC, 1980). Juveniles are found in and around shallow seagrass beds (especially *Thalassia* grass), shallow reef areas, mangrove roots, and jetties and pilings in preferred water temperatures of 63 to 85 ^{o}F (24 to 30 ^{o}C) (Thompson and Munro, 1974; Wallace, 1977). Adults are found on deeper reefs, and they tolerate temperatures ranging from 64 to 93 ^{o}F (18 to 34 ^{o}C) (GMFMC, 1980; Thompson and Munro, 1974; Roe, 1976).

E.5 ASSESSMENT OF IMPACTS AND MITIGATIVE MEASURES

As described in section E.2, only five of the proposed new and expansion sites would affect EFH. The locations of the brine disposal pipelines and the modeled brine plumes have been overlain on the designated EFH areas in the figures below for the Richton (figure E.5-1), Big Hill (figure E.5- 2), Stratton Ridge (figure E.5-3), Chacahoula (figure E.5-4), and Clovelly (figure E.5-5) sites. The brine plumes in these figures represent one of the two prevalent current directions. The depiction of the other prevalent current direction can be found in the draft EIS Appendix C on the brine discharge modeling. Based on the designated EFH areas and the species' life histories presented in section E.4, DOE has identified the species of concern in table E.5-1. This table presents the overlap between both estuarine and offshore EFH areas at each of the proposed expansion sites and the species that potentially would be affected.

The potential impacts to the EFH and managed fish species are common across all of the sites that have brine disposal pipelines and brine diffusers. In an effort to consolidate the discussion of impacts, the sites are grouped together as a general category of common impacts. The sites with potentially unique impacts are listed separately.

E.5.1 Common Impacts to the EFH

This section discusses potential impacts to the EFH that are common across multiple locations and are not dependent upon whether the object is an estuarine or marine component of the EFH. Water quality impacts and disruption of the habitat are two examples of the common impacts.

Water quality impacts to the water column would be caused by increased suspension of sediments generated from construction activities. The suspension of sediment in the water column may lead to an increase in heavy metal concentration in suspension and solution, but the effect would be temporary and very localized. The disturbance of the sediments during construction also may cause nutrients to become re-suspended and thereby trigger growth of plankton populations. Table E.5.1-1 shows the approximate footprint of disturbance for each of the alternatives that would occur to the estuarine and marine bottom from the installation of the brine pipeline. The area of disturbance is a very small fraction of the amount of similar habitat within the region.

The main impact on the water column would come from constructing the proposed brine pipelines, which would increase turbidity within the water column. The significance of this impact would depend on the type of substrate located along the ROW, the resettlement rate of the sediment, and the duration of the construction activities. For example, sediment particles of sand size or larger would settle quickly (in a matter of seconds) in the vicinity of the construction activity. On the other hand, smaller silt and clay particles would be transported greater distances by the currents before settling back down to the bottom. If the current velocity is 1 foot per second (0.3 meters per second) and the silt particles take 60 seconds to settle, they might be transported 60 feet (18 meters) from the construction area. There is some probability that the construction could disturb sediments that are contaminated, which would cause potential for contaminants to be released into the water column. DOE is not aware of different conditions among the alternatives that would make it more likely to encounter contaminated sediments.

Offshore pipelines would be strung together on barges and lowered to the floor of the Gulf of Mexico. After the entire offshore pipeline and diffuser had been strung together and placed on the floor of the Gulf of Mexico, a jet-sled would be used to bury the pipeline below the substrate. The jet-sled would direct high velocity water streams below the pipeline, thus removing the sediment below the pipeline and allowing it to sink.

Table E.5-1: Managed Species Potentially Effected By The Candidate Alternatives

	Richton		Big Hill		Stratton Ridge		Chacahoula		Clovelly*	
	Estuary	Offshore	Estuary	Offshore	Estuary	Offshore	Estuary	Offshore	Estuary	Offshore
Cobia	--	X	--	X	--	X	--	X	--	X
Dolphinfish	--	X	--	X	--	X	--	X	--	X
Greater Amberjack	--	X	--	X	--	X	--	X	--	X
King Mackerel	--	X	--	X	X	X	--	X	--	X
Red Drum	X	X	X	X	X	X	X	X	X	X
Red Grouper	--	X	--	X	--	X	--	X	--	X
Spanish Mackerel	--	X	X	X	X	X	--	X	--	X
Tilefish	--	--	--	--	--	--	--	X	--	X
Snapper										
Gray	X	--	X	X	X	X	X	--	X	--
Lane	--	X	--	X	--	X	--	X	--	X
Red	--	--	--	--	--	--	--	X	--	X
Vermillion	--	X	--	--	--	--	--	X	--	X
Yellowtail	--	X	--	X	--	X	--	X	--	X
Gulf Stone Crab	X	--	X	--	X	--	X	--	X	--
Stone Crab	X	X	X	X	X	X	X	X	X	X
Spiny Lobster	--	X	X	X	X	X	X	X	X	X
Shrimp										
Brown	X	X	X	X	X	X	X	X	X	X
Pink	X	X	X	X	X	X	X	X	X	X
White	X	X	X	X	X	X	X	X	X	X

* Note: The Clovelly-Bruinsburg alternative would potentially affect the same species since it would utilize the existing LOOP diffuser.

The other potential impact on the water column would be increased salinity from the brine discharge. The operation of the brine diffuser system would cause some changes to the physiochemical makeup of the water column. The brine discharge would be relatively constant for the duration of cavern solution mining (up to 5 years) and then would occur sporadically for drawdown or cavern maintenance. In the case of the Clovelly-Bruinsburg alternative, the period of brine discharge would only last about 3 to 4 years because of the smaller cavern capacity needed. The brine water would leave the diffusers at a rate of 30 feet per second (9 meters per second), at or near ambient temperature (68 °F, 20 °C), and at a concentration of approximately 263 parts per thousand. The area immediately adjacent to the brine port nozzles would have a modeled estimated salinity increase of 4.3 parts per thousand over the naturally occurring concentration (25 to 31 parts per thousand). (The brine discharge modeling reports that the value of the typical plume would be 4.3 parts per thousand, and the value for the maximum plume would be 4.7 parts per thousand).

Disruption to the species of fish, the EFH, and their prey would occur during the construction of the pipelines and brine diffusers and their operation.

Other common impacts would be caused indirectly to the EFHs or the species. A reduction in the prey for any of the managed species would have impacts to managed species populations. Prey reduction would result from the destruction of habitat, loss of food source, or incidental takings, which are impacts similar to those that affect the economically important species. In addition to mobile prey species, some sessile organisms would have an increased mortality from construction; however, the duration of the construction activities would be short and the affected areas would be relatively small.

During the construction phase of the proposed SPR project, the noise generated from the construction and support vessels may affect populations in the area. Depending on the species, the loudness (in decibels) and the frequency of the noise would create navigational disruption for some species of fishes. It is likely that noise and vibration from SPR project construction would cause species to leave the area. Once construction is complete, noise levels would return to normal and populations that vacated the area would return.

Table E.5.1-1 shows the estimated temporary impact to EFH from the construction footprint of the brine diffuser system.

Table E.5.1-1: Estimated Surface Area in Square Feet (Square Meters) of Estuarine and Marine Bottom Disturbed by Brine Pipeline Construction

	Big Hill square feet (square meters)	Stratton Ridge square feet (square meters)	Clovelly square feet (square meters)	Chacahoula square feet (square meters)	Richton square feet (square meters)
Temporary construction impact	N/A because new pipeline would not impact EFH	320,179 (30,550)	N/A because no new pipeline would be constructed	1,475,865 (140,600)	1,062,758 (101,250)

Note: The approximate area of disturbance was determined by calculating the length of the proposed offshore pipeline and the estimated width of the disturbance to sediments caused by the installation

E.5.2 Impacts to the Estuarine Component of the EFH

The estuarine environment throughout most of the proposed project areas already is disturbed. In some cases, the construction of the pipeline in estuarine areas would take place using directional drilling or would follow existing utility/pipeline corridors and canals. This would prevent adverse effects to the estuarine habitat.

The proposed construction of the brine pipeline would cause a temporary impact to this type of habitat, and many of its functions and value would be restored after construction is completed. Species that typically live within this habitat during one or all of their life phases would most likely leave the area during the construction phase of the proposed project. After the construction ceases, the fish populations would begin to return. There would be some local impacts where construction occurs, but the surrounding areas that remain undisturbed would allow the disturbed areas to quickly re-establish and function as habitat again.

The construction methods used for the pipeline installation would depend on several factors including cost, distance crossed, and habitat type. The clearing of the substrate to allow for burial of the pipeline would be the most intrusive part of the project, resulting in the greatest overall impact. Because of the construction, the concentration of suspended sediment would increase in the project area causing an increase in turbidity for a 1- to 2-day period immediately following construction (NEBC, 2003). Potential direct impacts to infaunal benthic communities resulting from the construction process include abrasion, clogging of filtration systems necessary for feeding and respiration, and burial and smothering. This impact also may be accompanied by harmful indirect effects such as changes in light attenuation leading to decreased feeding efficiency and changes in substrate composition (Berry, et al., 2003).

The survivorship of benthic invertebrates and other infauna in the project area is species- and location-specific. Many estuarine organisms have evolved mechanisms to survive changes in suspended and bedded sediment, and would not be affected by the project (Maurer, et al., 1986). Open water benthic organisms are less tolerant to sediment changes, and mortality rates would likely be higher offshore. Two vulnerable populations include mollusks, which would likely experience increased mortality and impaired growth rates in the project construction area, and demersal fish eggs that lie directly in the construction path (Berry, et al., 2003). Mature fish are fairly mobile, and likely they would leave the area during the construction process and return after completion.

The disturbance to suspended and bedded sediment may change the composition of the sediment, temporarily altering the distribution and relative frequencies of organisms in the infaunal community. Complete recovery of soft-bottomed benthic communities may take up to 2 years from the time of construction (NEBC, 2003). Even though the recovery period is long, the project area affected by construction is small relative to the amount of substrate habitat that exists.

The pipeline alignment and diffuser system for both Richton and Stratton Ridge would not be located in any known areas of seagrasses. The Richton pipeline would pass to the east of Gulf Islands National Shoreline, between a shipping lane and the barrier island. Given that the line is not passing over the barrier island or through known submerged aquatic vegetation, direct impacts from construction would not occur. Indirect impacts would depend upon the proximity to submerged aquatic vegetation.

If some submerged aquatic vegetation beds were to be affected by proposed pipeline ROWs, additional permits and approvals would be required and DOE would work with Gulf Islands National Seashore to restore those areas or rehabilitate other historical beds nearby.

E.5.3 Impacts to the Marine Component of the EFH

The impacts to the marine component of the EFH would be generated from the construction of the brine diffuser and the associated offshore pipeline. There would be two different methods of offshore trenching across the intertidal zone and barge construction with a jet-blasting sled.

The construction of the shore crossing at most locations would start from the shoreline, assemble the pipeline, and lay the pipeline in a trench that was already dug. The trenching method is a construction approach that permits low-cost construction and a shorter time frame. The construction impacts would be confined to the pipeline footprint and would be localized. The trenching method would disrupt habitat within the construction footprint only for a short time period during and immediately after construction (1-2 days). Each of the managed species would leave the area and return after completion.

Offshore construction would be conducted by barge and several support vessels. The pipeline would be first constructed on the barge and laid on the seafloor. After the pipeline was entirely assembled, a jet-blasting sled would then pass over the pipeline, burying the pipe below the sediment. The sled would straddle the pipeline and shoot high-pressure ambient water toward the sediment. After the sediment was removed from under the pipeline, the pipeline would fall into the trench created by the sled.

The main impact would come from the jet-blasting sled because it would increase the turbidity of the water column and cause mortality of sessile organisms unable to escape the immediate area. These sessile organisms would be a food resource for some of the commercially important species, and the reduction in the resource would affect some species populations; however, the construction footprint is relatively small and the duration of the construction is relatively short.

The operation of the brine diffuser system would cause some changes to the physiochemical makeup of the water column. For the Clovelly, Clovelly-Bruinsburg, and Big Hill sites the brine diffuser already exists and is already operating. Brine discharge would increase with the construction of new caverns for these sites. The brine water would leave the diffusers at a rate of 30 feet (9.14 meters) per second, at or near ambient temperature, and a concentration of about 263 parts per thousand. Consequently, the water immediately adjacent to the brine port nozzles would have a salinity of about 263 ppt. Moving away from the brine port nozzles, the salinity would decrease as the brine solution dilutes into the ambient environment and moves down current (see appendix C). The area of the mixing zone at a concentration of 4 ppt above ambient would vary by site and local conditions. At the Big Hill site, this plume would be as large as 4.3 square nautical miles (14.7 kilometers). Table E.5.3-1 highlights the ambient conditions at five of the sites. Table E.5.3-2 highlights the changes in the physiochemical characteristics that occur from the brine discharge.

Table E.5.3-1: Ambient Conditions at the Brine Diffuser Locations

Parameter	Texas		Louisiana		Mississippi
	Big Hill	Stratton Ridge	Clovelly*	Chacahoula	Richton
Ambient bottom salinity – average (ppt)	31	31	31	31	31
Ambient bottom salinity - worst case (ppt)	25	25	25	31	25
Ambient surface salinity - average (ppt)	31	31	31	25	31
Ambient surface salinity - worst case (ppt)	25	25	25	31	25
Ambient bottom temperature - average (F/C)	68/20	68/20	68/20	25	68/20
Ambient bottom temperature - worst case (F/C)	59/15	59/15	59/15	68/20	59/15
Ambient surface temperature - average (F/C)	68/20	68/20	68/20	59/15	68/20
Ambient surface temperature - worst case (F/C)	59/15	59/15	59/15	68/20	59/15
Water depth (feet/meters)	33/10.1	30/9.1	36/11	59/15	47/14.3
Ambient bottom current - average (meters per second; foot/sec)	0.30/0.09	0.30/0.09	0.30/0.09	30/9.1	0.30/0.09
Ambient bottom current - worst case (meters per second; foot/sec)	0.10/0.03	0.10/0.03	0.10/0.03	0.30/0.09	0.10/0.03

ppt = parts per thousand; F = Fahrenheit; C = Celsius
* Note: This would apply to the Clovelly-Bruinsburg alternative as well.

Table E.5.3-2: Changes to Ambient Conditions at the Brine Diffuser Locations

Parameter	Texas		Louisiana		Mississippi
	Big Hill	Stratton Ridge	Clovelly*	Chacahoula	Richton
Brine salinity (ppt)	263	263	263	263	263
Brine temperature (F/C)	68/20	68/20	68/20	68/20	68/20
Maximum number of ports	75	75	75	75	75
Number of open ports needed to reach maximum brine discharge rate	57	53	22	45	45
Port height above seafloor (feet/meters)	4/1.2	4/1.2	4/1.2	4/1.2	4/1.2
Port exit velocity (feet per second/meters per second)	30/9.1	30/9.1	30/9.1	30/9.1	30/9.1
Maximum brine discharge rate (MMBD)	1.3	1.2	0.5	1.0	1
Port diameter (inches/centimeters)	3/7.62	3/7.62	3/7.62	3/7.62	3/7.62
Port spacing (feet/meters)	60/18.3	60/18.3	60/18.3	60/18.3	60/18.3
Average area in plume for + 4 ppt salinity (nm^2)	1.2	1.1	0.4	see note A	0.9
Maximum area in plume for + 4 ppt salinity (nm^2)	4.3	4.0	1.7	see note A	3.4
Maximum vertical extent of brine jets – average (feet)	19	19	19	19	19
Maximum vertical extent of brine jets – worst case (feet)	18	18	18	18	18
Water depth (feet/meters)	33/10.1	30/9.1	36/11	30/9.1	47/14.3
Salinity increase downcurrent (ppt)					
1 nautical miles (average)	1.9	1.8	1.4	1.7	1.7
1 nautical miles (worst case)	3.4	3.3	2.3	3.1	3.1
2 nautical miles (average)	1.3	1.3	1.0	1.2	1.2
2 nautical miles (worst case)	2.5	2.4	1.8	2.2	2.2
3 nautical miles (average)	1.0	1.0	0.7	0.9	0.9
3 nautical miles (worst case)	1.9	1.8	1.2	1.7	1.7
4 nautical miles (average)	0.8	0.8	0.6	0.7	0.7
4 nautical miles (worst case)	1.5	1.5	1.0	1.4	1.4

ppt = parts per thousand

nm^2 = nautical miles squared

* Note: These results would apply to the Clovelly-Bruinsburg alternative as well.

A: Model predictions were calculated for Charcahoula, however not presented. This model was not designed to take into account the unique conditions of Ship Shoal.

The operation of the brine diffusers is one aspect of SPR operations that has the potential to adversely affect EFH. In addition to increasing the ambient salinity of the water near the diffusers, the brine can also introduce ions, metals, and other inorganics into the environment as contaminants. Based on studies of water characteristics and currently operational brine diffusers, projected brine plume modeling (see appendix C) showed that at all of the proposed sites – Big Hill, Stratton Ridge, Clovelly, Chacahoula, and Richton – salinity gradients would be generated if the proposed sites were developed. The modeling shows that there would be minor salinity peaks. Past analyses on brine contaminants showed that they can be present at slightly elevated levels around the diffusers, but that fish populations do not suffer adverse effects because the concentrations are low (Hann et. al, 1984).

The maximum amount of brine diffusion varies depending on the selected site. The Big Hill brine diffuser, which is located approximately 3.9 miles (6.3 kilometers) offshore, has the highest discharge potential at 1.3 MMBD. Stratton Ridge, which is about 3 miles (4.9 kilometers) offshore, is close behind at 1.2 MMBD. The maximum discharge from Richton and Chacahoula are lower, both at 1.2 and 0.7 MBD. The diffuser at those sites is located much farther offshore at approximately 14 and 17.5 miles (22 and 28 kilometers), respectively. The Clovelly and Clovelly-Bruinsburg alternative would utilize the existing brine diffuser of the LOOP facility to dispose of up to 0.5 MMBD of brine approximately 4 miles (6 kilometers) from shore. The Clovelly discharge is the lowest because much of the brine would be retained in the Clovelly brine pond system. For all brine plume models and impact assessments, the salinity of the brine was assumed to be 263 parts per thousand. This represents the saturation salinity for water at 68 °F (20 ^{o}C), which is slightly higher than the 250 parts per thousand levels previously observed at SPR diffusers in the past. The diffusers would sit 4 feet (1 meter) above the bottom and use a maximum of 75 potential diffusion ports spaced 60 feet (18 meters) apart, although no site would require 75 ports to operate at maximum capacity. The diffusers' depths and distances offshore vary by site, and the ambient salinity generally ranges from 25 to 31 parts per thousand at all sites, depending on the magnitude and direction of current flows.

Brine plume modeling was conducted for both an average-sized plume under typical conditions and the maximum plume under the most extreme environmental conditions. The brine dispersion modeling report indicates that "the maximum scenario is associated with an 18 centimeters per second current" and that the "large, typical and maximum scenarios [are] based upon the average percent occurrence of 0 to 3, 6 to 12, and 15 to 20 centimeters per second (see appendix C). The models provided +4 parts per thousand, +3 parts per thousand, +2 parts per thousand, and +1 parts per thousand contours for the typical and maximum plumes centered on the first brine diffuser port for each site. The brine plume contours were the largest at the Big Hill diffusion site because of its high brine discharge capacity of 1.3 MMBD. For Big Hill, the typical +4 parts per thousand contour is expected to cover an area of 1.2 square nautical miles (4.1 square kilometers), although that area would increase to 4.3 square nautical miles (14.7 square kilometers) under the maximum plume scenario. The total extent of the affected area for Big Hill, given by the area contained within the +1 part per thousand contour, was 7.2 square nautical miles (24.7 square kilometers) under typical conditions, but ranged as high as 24.4 square nautical miles (83.72 square kilometers) for the maximum condition and the +1 part per thousand contour. Brine contours were smaller at the other sites because of their lower diffusion capacities. Although the aerial extent of the brine plumes is large, the brine is heavier than seawater, and therefore, it spreads out along the seabed and does not reach the surface. Given the salinity and velocity of the brine exiting the diffusion ports, the maximum height for each plume is 18.5 feet (6 meters), which is well below the surface, even for the most shallow diffusion site, which is Stratton Ridge (30 feet, 9 meters).

The salinity increase from the brine diffusion is expected to have little or no direct impact on the fishery species in the Gulf of Mexico. The aerial extent of the brine plumes are relatively small compared to the total area occupied by the commercially important species. Furthermore, the fish and shellfish species managed in the proposed project area generally demonstrate high tolerances to changes in salinity beyond the potential +4 parts per thousand maximum salinity in the contour area. The shrimp fishery is the most profitable fishery in the Gulf of Mexico. Brown and white shrimp spend a large portion of their life cycle in estuarine environments, and they tolerate a wide range of salinity changes. Both species have been caught in salinity as high as 69 parts per thousand, which is almost double the highest projected value that can be attributed to the brine diffuser (Philips and James, 1988). Past studies indicate that a drastic increase in salinity may favor a switch in dominance from white shrimp to brown shrimp in the northern Gulf (Muncy, 1984). However, the overall impact on abundance of shrimp is expected to be negligible.

Other managed species, such as the finfish, also tolerate salinity ranges greater than what would be expected due to brine discharge. For example, Menhaden, for example, can survive in salinities up to

60 parts per thousand, and snappers and red drum are found in salinities between 45 and 50 parts per thousand (Lassuy, 1983; Reagan, 1984). Due to the freshwater influx from the Mississippi River, Gulf of Mexico species are generally euryhaline and able to tolerate salinity changes beyond what SPR operations would cause. Even in cases where species avoid the high salinities of the brine plume, the ambient salinity would return to normal levels quickly after the discharge ceases in about 4 to 5 years when the solution mining is complete. The species would repopulate the affected area fairly quickly after that period.

The species that would be most impacted from the brine discharge is the spiny lobster. Unlike the other managed species in the project area, adult and juvenile spiny lobsters are stenohaline and survive optimally in a narrow range of salinities from 32 to 36 parts per thousand. Furthermore, lobsters are confined to the benthic environments most affected by brine diffusion. Given the potential salinity changes associated with SPR operations, the proposed project would put the lobsters within the most concentrated salinity plumes at risk. Past studies indicate that lobsters exposed to high salinities relocate to areas of lower salinities (Butler, et al., 2002). This behavior continues until more favorable salinities are reached or metabolic demands associated with salinity stress lead to mortality. Given the relatively small area of the highest salinity contours (+4 and +3 parts per thousand), few lobsters would be affected and many would be able to move out of the high salinity range. Overall impacts to lobster populations are expected to be small and temporary.

Although the direct impacts to managed species are expected to be negligible, the impacts to benthic communities around the diffusion sites would temporarily impact the productivity of the environment. The heavy brine tends to sink to the bottom, and it would have a disproportionate impact on benthic species. Many of the commercially managed species in the Gulf of Mexico are demersal, and thus, they rely on the benthic organisms for a food supply. Depending on their salinity tolerance, sessile organisms (mollusks, worms) may be killed by the high salinity plume, and mobile organisms (fish, crustaceans) may be driven out of the mixing zone. Further, owing to currents, tides, storms, and other local events, neither the size nor the location of the high-salinity plume would be constant. Rather, it would move with changing conditions and affect an area of the water column and bottom that overall is larger than that estimated by the steady state models. Previous studies of the impact of brine diffusion on benthic biodiversity at the West Hackberry and Bryan Mound diffusion sites indicated a significant drop in benthic biomass within a range of 656 to 6,889 feet (200 to 2,100 meters) from the diffusers (Hann, et al., 1984). These findings are consistent with studies conducted at desalination plants that found drops in benthic macrofauna abundance around their brine diffusers (Argyrou, 2000). The change in benthic productivity would deter commercially managed species from inhabiting the project area. However, these effects would be negligible considering the relatively small area of decreased productivity compared to the surrounding unaffected area in the nearshore and offshore areas of the Gulf of Mexico.

In addition to raising ambient salinity levels, the introduced brine would cause a small increase in the concentration of metals and other inorganics in the project area. In previous studies of the West Hackberry and Bryan Mound sites, brine diffusion was accompanied by a slight increase in dissolved ion concentration compared to a control site, but all ranges were within the natural variability. The levels of nickel, copper, and lead did exceed Environmental Protection Agency (EPA) standards, but they were not significantly different from the levels observed at the control site. No evidence of any petroleum contamination was observed at either of the diffuser sites. Therefore, the operation of the brine diffusers is not expected to have a noticeable impact on water quality (Hann, et al., 1984).

A special case for the effect of brine diffusion on EFH would be posed by conditions at the Ship Shoal. Ship Shoal, located seaward of the Chacahoula site brine diffuser, is a depositional sand bar that rises from the seafloor of the 33 feet (10 meters) isobath to the 19 feet (6 meters) isobath. This sandy ecosystem is important for several fisheries, specifically white and brown shrimp and spotted sea trout.

The shrimp are important commercial fisheries, while the seatrout is an important recreational fishery. In addition, Atlantic croaker is a predatory species that is found on the shoal, but has limited commercial or recreational value. The area is being considered as a harvest site for sand used in beach replenishment, and the Mineral Management Service (MMS) is conducting an environmental assessment of the potential impacts of using Ship Shoal as a sand harvest site.

The construction of the brine disposal pipeline and the brine diffusers would not be close enough to Ship Shoal to have an adverse effect. The operation of the brine diffuser for the Chacahoula site would cause minor changes in salinity concentration near the brine diffuser, but the saturated brine would diffuse in the direction of ambient conditions in a short distance. The placement of the diffuser in the trough landward of the shoal would keep the highest salinity changes away from the shoal. DOE modified the orientation of the proposed brine diffusers at Chacahoula so they would be perpendicular to the brine pipeline and parallel to the primary current direction (see figure E.5-4). This modification would ensure more complete mixing and modify the shape of the brine plume so that it would not adversely impact Ship Shoal. The species found on Ship Shoal are euryhaline species, capable of tolerating a wide range of salinities. It is unlikely the brine would create a noticeable increase in salinity over present ambient conditions, but the species present would be able to tolerate the small and moderate salinity changes to the water.

E.5.4 Environmental Consequences of the Proposed Action

The environmental consequences of the Proposed Action, with respect to EFH, would be relatively small because the species of concern are found throughout the Gulf of Mexico region, and not limited to a specific area, and they are mobile enough to avoid areas of disturbance. The impacts caused by the construction activity would be localized to the immediate area of construction and would be temporary. The brine pipeline would be buried in the sediment and therefore would not permanently impact EFH or the water column. The only permanent footprint from the brine diffusers would be those from the diffuser ports, which are small (about 1 foot in diameter). Organisms that are intolerant of wide fluctuations in salinity would be killed by the high salinity plume or driven out of the mixing zone. The impacts to prey populations and managed species from the brine discharges have been shown by previous research to occur in a relatively small area. The discharges would comply with the National Pollutant Discharge Elimination System (NPDES) discharge limits that would be established by the resource agency with jurisdiction for the alternative selected. The permit would ensure that the water quality standards would not be violated by the discharge. Aquatic resources would not be adversely affected because the water quality standards are developed to protect aquatic resources as well as human health.

In addition, DOE would secure a Section 404 permit from the Army Corps of Engineers, a Section 401 Water Quality certification from the state, and a Section 10 Permit from the Coast Guard (if appropriate) for the proposed construction within jurisdictional waters including emergent wetlands. The permit would require avoidance and minimization of impacts to wetlands and waters (including EFH that qualifies as jurisdictional under Section 404) and compensation for unavoidable and permanent impacts. This compensation would require the preservation, restoration, or enhancement of other wetlands and waters or the purchase of credits from a wetland mitigation bank. This would ensure that there is no net loss of wetlands.

E.5.5 Proposed Mitigation Measures and Guidelines for EFH Protection

For trenching construction activities near or adjacent to EFH, the use of silt curtains would help reduce the amount of sediment that is suspended in the water body. While all increased sedimentation cannot be completely avoided, minimizing the sediment load would minimize the effects on fish and benthic organisms downcurrent.

Before construction begins, DOE and its contractor would examine the schedule and compare it to known spawning and migratory times of the year. This would be done to ensure construction would not interfere with routes used to reach spawning areas or impede migratory routes. This effort would minimize the disturbance to the EFH and to the species themselves during a more sensitive time of year.

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